

Higher order thinking in design reviews

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Abstract:

In this study we have grappled with how higher order thinking emerges in early stage design reviews, using an undergraduate dyadic review and a graduate review in a small group setting. Narratives, gambits and justifications emerged through a content analysis as forms of higher order thinking common in the reviews. We then mapped these reviews onto common frames of reference employed by teachers and students. Results depicted stark differences in the linguistic routines of the two teachers and two different sets of students. Each focused their higher order thinking from a primarily different frame of reference. Conclusions relate to opportunistic teaching strategies and the instructional tensions that the design review poses as a method for teaching the linguistic routines of the design review to early stage designers.

Keywords: Design critique, design reviews, content analysis, higher order thinking, discourse

1. Introduction

Researchers of design have long held the notion that the experience of the discourse of critique and review, in both its explicit and implicit forms, shape learners' views of what design is, is not, and what is expected of them as designers (Oak, 2000). Broadly, discourse-level analyses of pedagogical talk have revealed nuances of pedagogy across teaching disciplines and allow for insight into teaching practices otherwise unavailable through simple reflection (Fanselow, 1987). The implicit and explicit forms of discourse partially comprise what Dannels (2005) calls *ritualistic performances in the design community* (p. 152). For example, the pedagogical practice of moving from desk to desk and explaining what is "right" and "wrong" with learners' work is a ritual of design teaching and learning (Dannels, 2005; Schön, 1983). She argues that these rituals are the community performing its culture, and that each role plays its own part: the student, the master (or professor) and the onlookers (Dannels 2005, Anthony 1991). Prior to Dannels, Hymes (1972) took a similar perspective in his assertion that there are *linguistic routines* inherent in every profession, such as the lines of questioning attorneys or law enforcement officers use in their work. In this paper, we have assumed a lens that looks at the performances of *linguistic routines* (Hymes, 1972, p. 287) separate from the frames of reference (Dorst & Cross, 2001) interlocutors use to address the topics of design reviews. These studies construct a foundation for

the utility in investigating the linguistic routines inherent in design reviews, but other studies informed our perspective of the characteristics of communications that might take place in these designs reviews.

Dannels and her colleagues have investigated the types of language that emerge in the process of design reviews. Dannels and Martin (2008) investigated design critique discourse and came up with a feedback typology consisting of, in order of frequency, judgments, process orientation, brainstorming (ideation and hypotheticals), interpretation, recommendations, investigations (queries), free association, comparison, and identity invocation. From this data they interpreted that the primary educational goals were of two kinds: to direct students to do certain things, and to facilitate in learners the creation of a viewer based mindset (Dannels & Martin, 2008). Dannels, Gaffney, and Martin (2008) evoke a broader discussion about the expectations that surround communication through the design crit.

Others have focused on the types of learning that can be identified as emerging via design reviews. Interestingly, Exter, Korkmaz, and Boling (2009) looked at the critique process, and proposed four stages of development in learners' understandings during critique: mechanical, practical, conceptual, and integrative. Jeffers (1994) solicited learners' experiences of critique and concluded that learners both recognize the value of the critique as essential to their learning, and often have painful associations with the experience of the event. Senturer and Istek (2000) take a wider lens on the discourse of design thinking, including media representations and visuals, and conclude that the discourse of design education is the most influential in shaping designers and has great impact on their subsequent designs. Gray (2013a, 2013b) also follows in this framing, looking at the discursive structures of peer critique, and the ways this form of critique causes the students to construct identity and awareness of their role as a designer within the larger pedagogy.

Lastly, others have focused on what language should be promoted by design reviews, but often is not. Morton and O'Brien (2006) discuss how pedagogy (in graphic design particularly, but more broadly applied to design education) should hone design skills for "selling your design"—adding the ability to articulate designs to an audience to the already assumed technical design competence. Gray and Howard (2014) identified normative concerns that are missing in design reviews, and Cardoso, Eris and Badke-Schaub (2014) highlight the paucity of high-level questions that invoke causative and generative thinking in learners.

All of these studies recognize that critique discourse as an essential part of design pedagogy, and often assume a common analytical practice of combining the frames of reference of the discourse with the strategies used to express it. This is evident in Dannels and Martin's (2008) feedback genres. For example, expressing a *judgment* is a common speech act, how one goes about their discourse. However, a *process orientation* is what someone is talking about, the frame of reference from where the utterance originates. It is quite possible to express a judgment about a process orientation, but both are treated as genres of design communication (Dannels & Martin, 2009). Combining discursive strategies with topics is a logical approach because the content of learning cannot be separated from the strategies used to teach it (Papert, 1980). However, there is a descriptive advantage to separating discourse strategies from frames of reference. Howard (2012) found that the separation supported an analysis that could expose circumstances under

which discursive strategies (namely, discursive practices indicative of higher order thinking) were more likely to occur. For example, when learners problematized their own observations within the frame of reference of another, discourse indicative of higher order thinking was between two and three times more frequent (Howard, 2012).

1.1 Higher order thinking as a pedagogical objective

“Higher order thinking occurs when a person takes new information and information stored in memory and interrelates and / or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations” (Lewis & Smith, 1993, p.136). Higher order thinking is also distinguished from critical thinking and problem solving; the former focusing on evaluative and judgmental priority and the latter being a sub-component focused on practicality (Lewis & Smith, 1993). The Lewis and Smith (1993) definition is somewhat general as all studies of higher order thinking operationalize the term differently (Booth & Hultén, 2003; Garrison et al., 2001; Gunawardena et al., 1997; Hara et al., 2000; Henri, 1992; Howard, 2012; Marra, 2006; Marra et al., 2004; Newman et al., 1997; Pena-Shaff et al., 2001; Pena-Shaff & Nichols 2004). These empirical studies of higher order thinking share a conclusion that higher order thinking is an interrelation of component parts, is recognizable, that it manifests differently in different contexts, and is a highly desirable pedagogical outcome.

Higher order thinking is desirable because it is highly transferable (Resnick, 1987). Schön (1987) argues that it is this transferability of cognitive processes that advantages a designer when in the often-occurring contexts of uncertainty. While a pedagogical focus on promoting higher order thinking first came into mainstream discussions with Bloom et al.’s (1956) work on instructional strategies, Krathwohl, a colleague and co-author with Bloom, revisited and refined the taxonomy, separating knowledge and cognitive processes (2002). Higher order thinking was comprised of the upper four of six cognitive processes, in the following sequence: applying, analyzing, evaluating and creating (Krathwohl, 2002), though it can hardly be said that any one of these is “higher” than another as they are qualitatively different cognitive functions (Howard, 2012). It is these four cognitive processes that educational researchers have mapped over varying coding schemes to come up with analyses of discourse to determine how higher order thinking manifests in different domains. Table 1 provides four different coding schemes designed for different disciplines within education, and denotes discursive strategies indicative of higher order thinking via an asterisk.

Table 1: Four analytical schemes focusing on methods of identifying higher order thinking in different fields of education. Bracketed insertions are our own elaborations drawn from detailed descriptions in the cited manuscripts.

Garrison (1992)	Gunawardena (1997)	Booth & Hulton (2003)	Howard (2012)
[Adult education]	[Distance	[Engineering education]	[Teacher education]

education]			
1. Problem identification*	Information sharing	Participatory contribution [identifying oneself, acknowledging others]	social discourse
2. Problem definition*	Discovery and exploration	Factual contributions	Observations
3. Problem exploration [checking for understanding]*	Negotiation and knowledge co-construction*	Reflective [Problematizing] contributions*	Analytical statements and questions*
4. Problem applicability [evaluation]*	[Hypothesis] Testing and modification*	Learning contributions [discerning, refining, opening dimensions of variation]*	Applications of new ideas*
5. Problem integration [applying new ideas]*	Application of newly constructed meaning*		Acknowledgements of the unknowable from given information*

In each of the approaches in Table 1, researchers have discerned how applying, analyzing, evaluating, and creating manifest in these different disciplines in education via grounded inquiry into specific pedagogical discourse, though not all of the cognitive processes appear explicitly on every scheme. The identification of higher order thinking in design reviews is descriptive in nature, but serves the purpose of informing design pedagogy. In design education, discerning how higher order thinking manifests in the design review holds a unique value if discursive strategies can be juxtaposed with frames of reference, even on a rudimentary level, because the framing of a problem often leads to or symbiotically co-occurs with a designer's solution (Dorst & Cross, 2001; Schön, 1987). In short, it would be helpful to have a greater understanding of how higher order thinking is likely to manifest in design reviews, and how this form of thinking differs between the roles of teacher and student.

Within the ritualistic linguistic performances in design reviews, some performances will denote more transferable discursive strategies of higher order thinking, and these may or may not appear in different frequencies in relation to certain frames of reference. Before such an analysis can be done, higher order thinking as it manifests in design reviews must be discerned and isolated. Therefore, we posed these three subsequent three research questions in this order:

1. How is higher order thinking expressed in these design reviews?
2. What are the frames of reference that comprise the reviews?

3. How is higher order thinking expressed across different frames of reference by the two roles of teacher and student?

2. Methods and procedures

Content analysis allows for a separation of the strategies interlocutors use to discuss topics, and the frames of reference from which they address these topics. The relationships between different aspects of communication have offered insights into new areas of pedagogical inquiry and show the potential to reveal new perspectives on communication (Herring, 2010). For example, Herring (2010) looked at the topics of blogs and the number of in-bound links those blogs had in order to develop an understanding of hypertext as part of online communication. A content analysis requires that categories be developed or adapted to fit each classification in order for relationships to be studied (Bauer, 2000).

In this study, we first developed a content analysis scheme by adapting previous content analysis categories used in other educational disciplines (see Table 1). We then developed a second scheme via a grounded approach to describe the frames of reference teachers and students employed. The joint occurrences of discourse strategies and frames of reference describe the *ritualistic performances* at the discourse level in these design reviews. We paid special attention to the *higher order thinking* represented in these reviews, as it is a pedagogical point of interest in nurturing design thinking in learners.

2.1 Data Selection

We selected a purposive sample from the DTRS data set (Adams & Siddiqui, 2013) of two industrial design transcripts, one graduate with four interlocutors (Mylie, Allison, Dan and Simon) and one undergraduate dyad (Todd and Gary). Since this stage included developing the codebook for the content analysis, we valued the diversity of the sample over collecting a larger and more homogenous sample. We selected the initial meetings (first reviews) because we reasoned the process of ideation and initial teacher student discussions would contain more externalized higher order thinking than reviews where the majority of the higher order thinking had already taken place in the visuals being discussed. We chose one graduate and undergraduate review to hopefully balance the sample, and provide a view as how these routines might vary across contexts. The two transcripts resulted in a corpus of approximately 8000 words, comprised of 50 minutes of teacher-student interactions and 554 segments of teacher-learner discourse. The corpus was saved in Microsoft Excel to enable coding and analysis.

2.2 Locating higher order thinking in design reviews

Locating higher order thinking required that a manageable number of descriptive categories be developed, and that they be as mutually exclusive as possible given the uniqueness of the data. As is common in content analyses of discourse, the unit of analysis was generally the conversational turn (Widdowson, 1978), except in cases where a significant change in strategy occurred. In such cases, turns were split into segments, or if one turn was only split by social interaction, such as a backchannel utterance that confirmed that the other was in fact listening (e.g., ah huh, hum, yes, etc...), the turn was combined (Herring, 2001). Only the externalized interrelation or rearrangement of new and stored information were identified as performances

that evidenced higher order thinking (Lewis & Smith, 1993). With the goal of identifying performances that externalize applying, analyzing, evaluating, and creating, the first author attempted to code the discourse according to the taxonomy previously used in teacher training (see Table 1: Howard). The taxonomy did not map onto the data set, but provided a guide to the development of new category codes within the discourse strategy classification. Content analyses of discourse often align closely with speech act analyses because both attempt to disambiguate discourse strategies in situ. An important difference is that content analysis often merges speech acts into single categories in order to shed light on specific aspects of discourse. I have highlighted areas where speech acts from the McNair, Parette and Groen (2014) speech act taxonomy might have been applied to these data in order to allow a discussion of comparative findings among the two data sets selected from the DTRS collection.

The example in Table 2 depicts a coded higher order discourse strategy from teacher training juxtaposed with an example in a design review that expresses a similar form of higher order thinking but appears in the form of narrative.

Table 2: Juxtaposed examples of analysis (higher order thinking) taken from the DTRS data and undergraduate teacher training (Howard, 2012).

Teacher education discussion	DTRS design review
“Given that there was such little interaction from students I feel as though the lesson wasn't very effective or engaging. I would say it is efficient only if students understood [the] purpose of the activity, and that's not happening with such little interaction.”	Um, but we actually divided it, um, like understanding family. It was interesting to see the difference between young families versus families with kids. So we took a broad approach in terms of young families that had married, moved in together, not kids yet.
Substance code: analysis	Substance code: narrative

In the example from teacher training (Howard, 2012, Table 2), the learner has interrelated new information (“such little interaction from students”) with their previously acquired understanding of what is effective and engaging teaching, and then drawn a qualified conclusion from this interrelation. The learner concludes that is it “not happening with such little interaction.” Such an interrelation happens in the design review, but the performance appears in narrative form. The student makes note of an observation that resulted in the division of certain aspects of her designing, where she had drawn a conclusion on a course of action based on her curiosity about what she was observing in comparison with what she may have expected. While clearly analysis has taken place, the discourse strategy, or *linguistic routine* (Hymes, 1972), is narrative because the emphasis is on a recounting rationale, not simply expressing it. In McNair, Parette and Groen (2014), aligning speech act categories include *clarify*, or the likely response to, *promote reflection*. Narratives were operationalized as the recounting of a set of events related to the design. A similar dynamic took place in cases where learners applied knowledge.

Table 3: Juxtaposed examples of application or creation (higher order thinking) from the DTRS design reviews and undergraduate teacher training (Howard, 2012).

Teacher education discussion	DTRS design review
“Overall the teacher was great. BUT, If he had given the learners just a little time with the technology, just to try it out, they might be a lot more engaged with [when] the directions came along later on for how to use the tool correctly.”	Um, yeah. It'd be pretty simple. Um, and then like I, I can just imagine this like a wall like on the side and it could just be like almost decorative, but it would be like stored. So that, that would be cool. Um, that's three. I, I really like these shapes. I don't know if they're very – if, if that's what they're looking for or not. Um –
Substance code: application	Substance code: gambit

In the example from teacher training the learner has interrelated new knowledge from an observation with previous knowledge of a teaching tactic, and come to the conclusion that this is a location to apply the tactic fortuitously. This was coded as application, one of three forms of higher order thinking in the observation system applied in Howard (2012), because the student has applied one process to a new context. In the example drawn from the design review, the learner also puts forward a suggestion for action, creating “like a wall like on the side...but it would be like stored.” The application of knowledge in the design review is expressed not as a directly applicable tactic, but as a value proposition based on a reasonable guess. The learner expressed the values “simple” and “cool” and having an affinity for “the shapes” as components of their higher order rationale. While the discourse clearly expresses the components of higher order thinking, interrelating new information and stored information to achieve a purpose, the proposed course of action comes across with far less conviction. The learner in the teacher training context uses only one softener, “might” while the learner in the design review uses in the range of six to nine softeners, “Um, Um...like, I can just imagine, would be, I don't know,” and “if.” The term *gambit* (Lawson, 2006) more accurately describes the cognitive process than the term *application*. Gambits were operationalized here as hypothetical or proposed design choices. McNair, Paretti and Groen (2014) labeled similar discourse in the mentor role as *advise*.

Another category of higher order thinking is evaluation, and in this respect the two data sets diverged dramatically. The recognition of justified and unjustified claims about teaching is an important aspect of teacher training, but it was the justifications themselves that came to the fore in the design reviews.

Table 4: Juxtaposed examples of evaluative reasoning (higher order thinking) from the DTRS design reviews and undergraduate teacher training (Howard, 2012).

Teacher education discussion	DTRS design review
“I understand your point about keeping it simple, but if we don't know their prior experience with this technology, we really can't figure out what simple is for these learners.”	‘Cause your job, your job is to bring something exciting –into the workplace. Yeah, 'cause you're really hiding, you get support structure and then inside, it offers a kinda like some drama and some edginess to it.

	Just still, um, because these ideas can also sometimes lead to ideation processes so we kind of wanted to actually pull them out.
Substance code: acknowledgement of the unknowable or <i>intellectual modesty</i> (also see Preston, 2010)	Substance code: justification

In the example taken from teacher training in Table 4, the criticism regards an unjustified claim, but in the discourse drawn from the design review, the three examples are justifications of previous statements, and lack the explicit elements of interrelation typically present evaluative higher order thinking strategies present in the other data. In the design reviews, evaluative turns invoked supportive reasoning, suggesting that “selling the design” (Morton & O’Brien, 2006) or justifying the directive was an important aspect of the linguistic routines of design reviews. The addition of rationale was so common in the design reviews, that a number of different terms could have been applied, such as *elaboration*, *additional rational*, or *explanation*. This also suggests that indeterminacy of the task requires that these interrelations of information appear in unpredictable and organic forms, rather than something that could easily be categorized with a simple code. We settled on the term justification to express a general discursive strategy rather than as an explicit descriptive term. Notice that the third example taken from the design review contained interwoven elements of narration. Since the content analysis method we employed required exclusive coding such cases required a judgment regarding what code was most evidenced in the turn or turn segment. Justifications were operationalized as rational or additional or supportive information related to the process, the design or the task. These same discourse strategies are echoed in McNair, Paretti and Groen (2014) with their codes of *evaluate*, *extend* and *protect*.

The parsing of the two design reviews in search of the discourse strategies that evidenced higher order thinking were iteratively brought into three categories: *narratives*, *gambits*, and *justifications*. Extensive narratives contained the interrelation of new and acquired information, resulting in explanations of choices made rather than conclusions drawn about designing. Gambits were plentiful; however, absent were acknowledgements of the unknowable given the information available and explicit applications of previously learned content. Evaluative strategies took the form of additional explanation that included reasoning, and suggested that multiple reasons for actions (justification) was an aspect of higher order thinking in the design reviews that was not so prevalent in the educational discussions.

Non-higher order thinking strategies were social, confirmative, inquisitive or directive in nature. This process resulted in a content analysis scheme of seven codes, three of which were deemed higher order thinking in the design reviews.

2.3 Problematic cases in identifying higher order thinking

In these design reviews, higher order thinking was oftentimes co-constructed, and in other cases executed via shorthand. Interlocutors went so far as to even complete each other's sentences, as in the examples shown in Table 5 taken from both undergraduate and graduate design reviews. These shorthand-half finished turns made higher order thinking difficult to identify. In the example in Table 5, Gary (teacher) and Todd (student) engage in ideation (a form of higher order thinking because it interrelates new and existing stored information) via shorthand shared between them. We reasoned this was co-created higher order thinking, but in so, is difficult to attribute to either party. In Turn ID 439, Gary's turn is split by Todd's gambit. Todd suggests a design move, using "two different colors." Gary follows with more gambits in turn 440. Both are examples of higher order thinking in the context of a design review. In this taxonomy, each is coded as a gambit because they are hypotheticals, interrelating previously expressed aspects of the artifact to consequential design moves. A similar dynamic takes place in the graduate design review where Mylie expresses a possible course of action. We concluded that the co-creation of higher order thinking should be attributed to both as both were engaged in recognizing and using the mentioned or unmentioned information to come to their own gambits.

Table 5: Co-constructed higher order thinking in undergraduate design reviews (lines 439,440) and graduate design reviews (line 465).

Turn ID	Speaker	Role	Talk	Substance	Frame of reference
438	Gary:	T	That'd be good, and then –	recognition	quality of the artifact
439	Todd:	S	– two different colors.	gambit	quality of the artifact
440	Gary:	T	And maybe that bottom piece could be a – actually, again, they do wood veneers. They can do wood presses, which tooling isn't that expensive. So maybe that's a place you can throw in a wood veneered base.	gambit	quality of the artifact
441	Todd:	S	Yeah.	social	quality of the artifact

464	Simon:	T	Okay, translating them into – is it – I think sometimes more is not better so maybe if you can ...	recognition	objective design knowledge
465	Mylie:	S	Synthesize it.	gambit	process orientation

466	Simon:	T	... get like – eliminate some that are either redundant or ...	directive	process orientation
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Deixis, or the presence of a conditional reference, forced the coder to assume logical relations hinted at within turns though not explicitly stated. Many interrelationships among features of the designs, the design presentations, or aspects of the user experience research, were implied with pointing or gesture as the visuals comprised a significant portion of the basic communication itself (McNair, Paretto & Groen 2014; Schön, 1987). Not all narratives initially seemed to attain clear interrelations though the design review continued as if these relationships between features were clearly understood. Some turns appeared as simple narratives, but on close inspection, could be assumed to contain more interrelation based on the context of the discourse—a design review is based on the assumption that all the discourse is somehow related to the design at hand. In Table 6, Mylie recounts the teams’ experience in order to describe her design, and we have inserted in brackets the omitted discourse understood between the interlocutors based on the context of the design review.

Table 6: A learner uses higher order thinking to relate multiple aspects of her design experience to unstated decisions in her design.

Turn ID	Speaker	Role	Talk	Substance	Frame of reference
111	Mylie:	S	And here [we chose this particular solution because] although it doesn’t color-wise, here [we chose this alternative solution because] we synthesized the kind of the, the kind of user type.	narrative	process orientation

In Table 6, “here” is an example of deixis, and this was employed extensively through the design reviews. We reasoned that an analysis of higher order thinking should recognize these implied interrelations of information understood between interlocutors in order to truly reflect the linguistic routines of the design review. The large amount of deixis in the corpus posed coding issues in locating higher order thinking because the accuracy of these assumptions of interrelated information could not be confirmed.

2.4 Developing the content analysis scheme for frames of reference

A second classification type was employed to relate the substance types to recurrent frames of reference. Transcripts were read closely for perspectives that emerged from the data itself. Discussion in the design reviews was not confined to discussion of the artifacts themselves, but rather followed tangents including (1) expressions of objective knowledge about designing and scientific or pseudo-scientific design principles about the act of designing, (2) inquiry and explanations of the design process or process orientation, (3) an orientation to the presentation of the design or how it that presentation might be viewed, (4) the assumed perspective of the

intended user, (5) discourse management or procedural management taking on the role of organizing speech or supporting the flow of the discussion, and (6) of course, a focus aimed clearly on the quality the proposed designed artifacts themselves. Table 7 provides examples of each frame of reference drawn from the data. The frame of reference classification appeared to have utility in characterizing the linguistic routines because clear orientations did emerge. The grounded method to develop the coding scheme for frames of reference required several passes of over one-hundred turns to aggregate from an initial set of twelve to a manageable six. But we felt this still provided enough nuance to characterize changes in perspectives assumed by the different roles.

Table 7: Examples of frames of reference

Turn ID	Speaker	Role	Example	Substance	Frame of reference
290	Mylie:	S	Kind of videoed themselves and just video, which actually proved quite helpful because they narrated every time they did. It was kind of a, um, we didn't have to probe.	narrative	process orientation
427	Dan:	S	And at the moment, I think they're having trouble with that with the fact that they're in grade school and they have their own homework and stuff to do and extracurricular activities.	narrative	user experience
533	Gary:	T	Let's pull them out again.	directive	discourse management
270	Simon:	T	So you – it just increases contrast and so subtle things. The other thing that can happen is the light images disappear altogether. I had something there but now it's white.	recognition/ clarification	objective design knowledge
258	Simon	T	Yeah, your text. You've got great text on background image and it's really starting to – the other thing is you're running your lines which is fine that every page –	recognition/ clarification	presentation orientation
655	Todd	S	Oh, that'd be cool. Yeah. If it was just like cut, maybe all fit together.	gambit	artifact orientation

3. Results and discussion

We present the following measures for the graduate and undergraduate sample not to make an evaluative comparison, but simply to show two different dynamics of design reviews, and their relationships to the emergence of higher order thinking in the two contexts as part of the linguistic routines in the roles of teachers and students.

3.1 Basic Participation

Basic participation measures orient the reader to a set of results regarding a corpus of communications, and because turns can be of varying lengths, word counts are often a more accurate description (Herring, 2001). There were 425 more words in the graduate sample of 4310 words as compared to the undergraduate sample of 3885 words. It is important to notice that the graduate sample design review lasted 30% longer than the undergraduate review, 29 minutes as opposed to 20 minutes in the undergraduate review. The linguistic routines are more apparent when viewed in normalized numbers and according to teacher /student role. In Figure 1, we see that in the graduate sample, students held the floor longer. The dynamic was reversed in the undergraduate sample, where the teacher held the floor longer. When the participation is viewed in normalized as percentages in the two reviews separately, the teacher dominated the discourse more in the undergraduate design review.

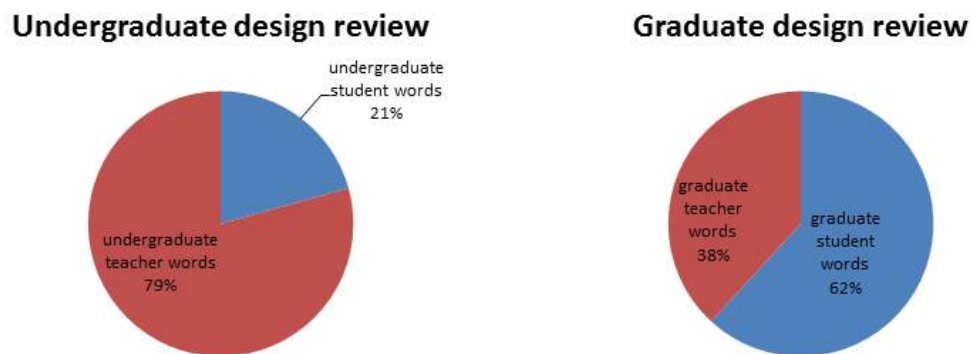


Figure 1: Normalized word counts in the student and teacher roles in an undergraduate and a graduate design review.

A similar dynamic played out in how long the floor was held by participants in the two roles on average across their conversational turns. The undergraduate learners had, on average, much shorter conversational turns than the teacher, while graduate students, on average, held the floor longer than their teacher. Figure 2 show the average lengths of conversational turns in words by role in the two design reviews.

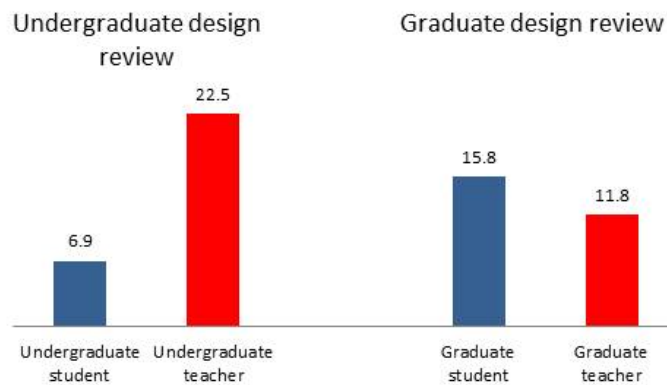


Figure 2: Students and teachers average lengths of conversational turns in words in the two design reviews.

These two perspectives on basic participation suggest that the linguistic routines in the roles of teacher and student played out differently in the two undergraduate and graduate design reviews. The teacher held the floor longer, and more than three times as long on average, in the undergraduate design review. Whereas in the graduate design review the lengths of the teacher and student roles tipped in favor of the students, but was more balanced. Students only averaged 4 more words per turn than the teacher in the graduate level reviews.

3.2 Higher order thinking in design reviews

Substance measures offer a description of how teachers and learners constructed their discourse strategies in the different roles. Figure 3 provides normalized frequency measures for the substance types of the turns for both design reviews in both student and teacher roles. Higher order thinking was dispersed radically differently in the two design review contexts. In the undergraduate design review, verbalized higher order thinking comprised only 12% of learner turns. In the graduate design review, it comprised 44%, primarily because of the many turns devoted to narrations. The higher order thinking turns in relation to the total turns for each role were as follows: for undergraduate students 14/116 (12%), undergraduate teacher 32/137 (23%), graduate student 72/164 (44%), and the graduate teacher 18/139 (12%). Incidentally, higher order thinking percentages from teacher training critiques of practicing teachers at the undergraduate level ranged from 22% to 40% as reported in Howard (2012); these design reviews had a far greater variance in higher order thinking participation on the whole. Ideation processes, or gambits, were evidenced to a greater extent in the undergraduate review for both students and the teacher. While both design reviews may have been at an early stage in the design process, the visual communications the learners put forward seemed to play a different pedagogical role in relation to higher order thinking. In the undergraduate review, they served to further higher order thinking through ideation, while for the graduate students, they provided a starting point to explain and justify the process of design that had been undertaken.

Frequencies of non-higher order thinking substance also shed light onto the linguistic routines. The large number of turns in the undergraduate design review coded as *social* reflects a nuance of linguistic routine. Many of these turns were confirmations that the student was listening to the

instructor, such as “Yeah,” “Mm-hmm,” and “Okay.” These were short turns where the learner did not take the floor for an extended length of time. Whereas in the graduate design review, students took the floor and provided narratives of the user experience they viewed, or their design process.

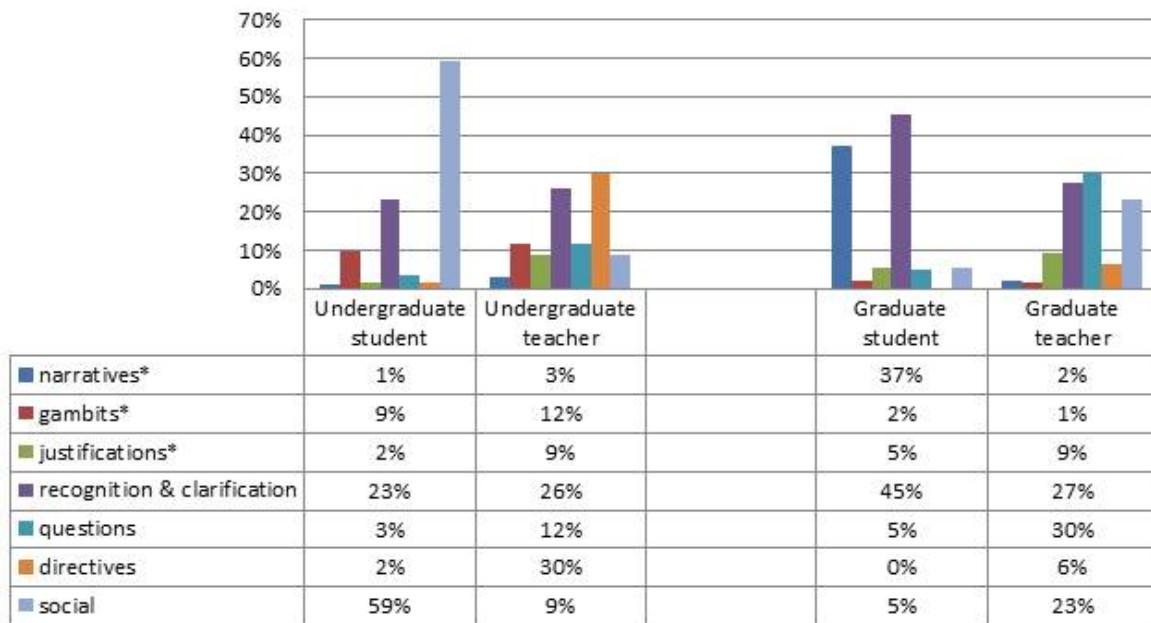


Figure 3: Conversational turns devoted to each substance type normalized into percentages of student or teacher discourse in undergraduate and graduate design reviews with higher order thinking turns marked with asterisks, *.

In both design reviews, characteristic teaching behaviors of asking questions and giving directives was pronounced, 42% in the undergraduate design review and 36% in the graduate review. In the undergraduate design review, the teacher gave far more directives than asked questions, and in the graduate review asked more questions than they gave directives. This suggests that the dynamic of the teaching and learning was quite different in the two contexts; in the undergraduate role the teacher assumed the task of giving directions while in the graduate review, the teacher assumed more of a questioning role.

3.3 Frames of reference in the design reviews

Frames of reference frequencies describe the orientation from which speakers addressed the design reviews. Normalized frequencies of turns in each role in the two design reviews are presented in Figure 4. A presentation orientation figured prominently in the teacher role in both undergraduate and graduate design reviews, 26% and 21% respectively. However, in the undergraduate review, a presentation orientation was not the most often assumed perspective; rather, an artifact orientation focused solely on the quality of the artifact itself occupied more teacher turns, 33%. Reference from the position of imparting objective design knowledge appeared as the most explicit "teaching moments" in these design reviews. These were moments

where the teacher seemed to want the students to notice or learn something in particular, bridging off the students' work to explain scientific or pseudo-scientific principles of design, or the nature of design itself. These segues comprised approximately 15% of the teacher turns.

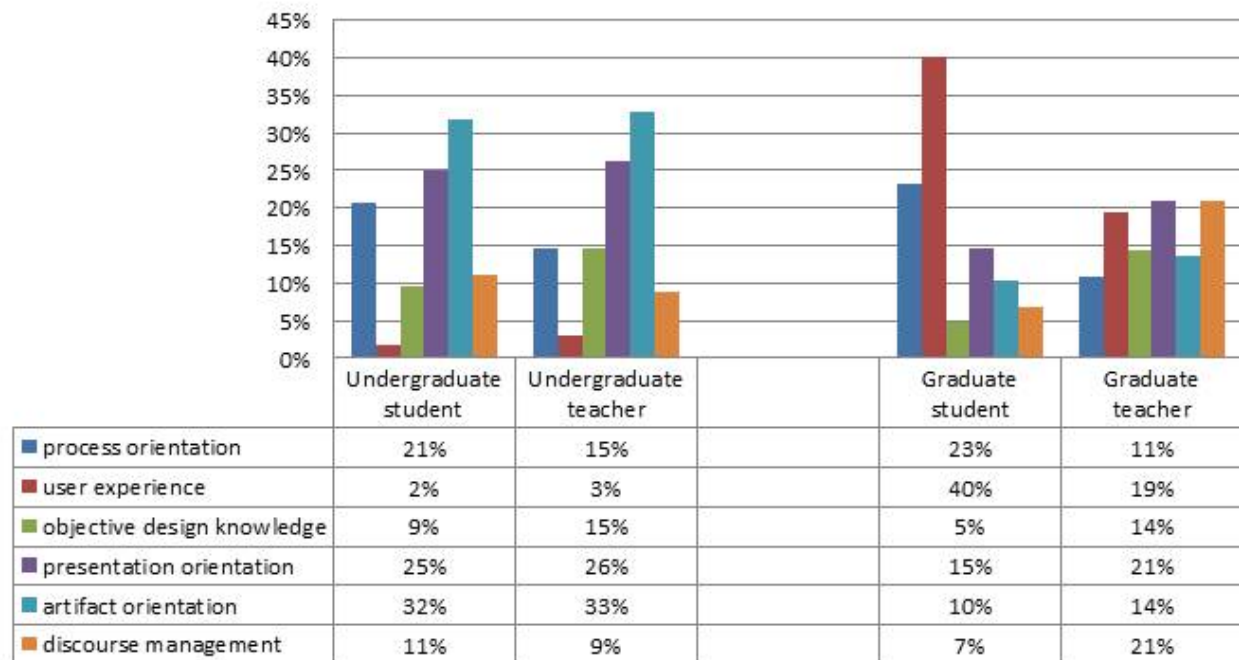


Figure 4: Conversational turns from different frames of reference normalized into percentages of turns in graduate and undergraduate design reviews in two different roles.

For learners, more so than for teachers, a process orientation occupied a large number of their frames of reference, 21% and 23%, in the undergraduate and graduate design reviews respectively. One might expect a process orientation to be configured the other way around between the roles of teacher and student. Instead of the teachers digging into the process of design, rather, it was the students explaining their processes that resulted in the frequencies of process orientation in the samples.

An orientation to the user experience was far more present in the graduate design review, occupying 40% of the learner turns and 19% of the teacher turns as opposed to 2% and 3% in those roles in the undergraduate design review. This may reflect how the two instructors envisioned their teaching roles, similar to the substantive dynamic mentioned previously where the graduate teacher spent 30% of his turns on questions, while the undergraduate teacher spent 30% of his turns on directives. It is curious that the user experience oriented turns of the undergraduate teacher were phrased as directives, as if the instructor were directing the user experience rather than exploring it. Table 8 presents this example.

Table 8: An undergraduate teacher phases a statement regarding the user experience as a directive to the hypothetical user.

Turn ID	Speaker	Role	Talk	Substance	Frame of Reference
359	Gary:	T	You know, it's just you, you go in there and you're comfortable and you, you – and you, you move quickly, a SWAT team. On it, go someplace else.	directive	User experience

3.4 Higher order thinking across frames of reference

Since higher order thinking reflects the linguistic routines that interrelate new and old information to achieve various purposes, it is arguable that Figure 5 reflects the frames of reference from which interlocutors in the different roles invested their most significant cognitive effort. In Figure 5, the frequencies are normalized to the total number of higher order thinking turns for interlocutors in that role, not the total turns in each role. (See Figure 3 for those measures.) Figure 5 depicts higher order thinking across frames of reference normalized to the total number of higher order thinking turns.

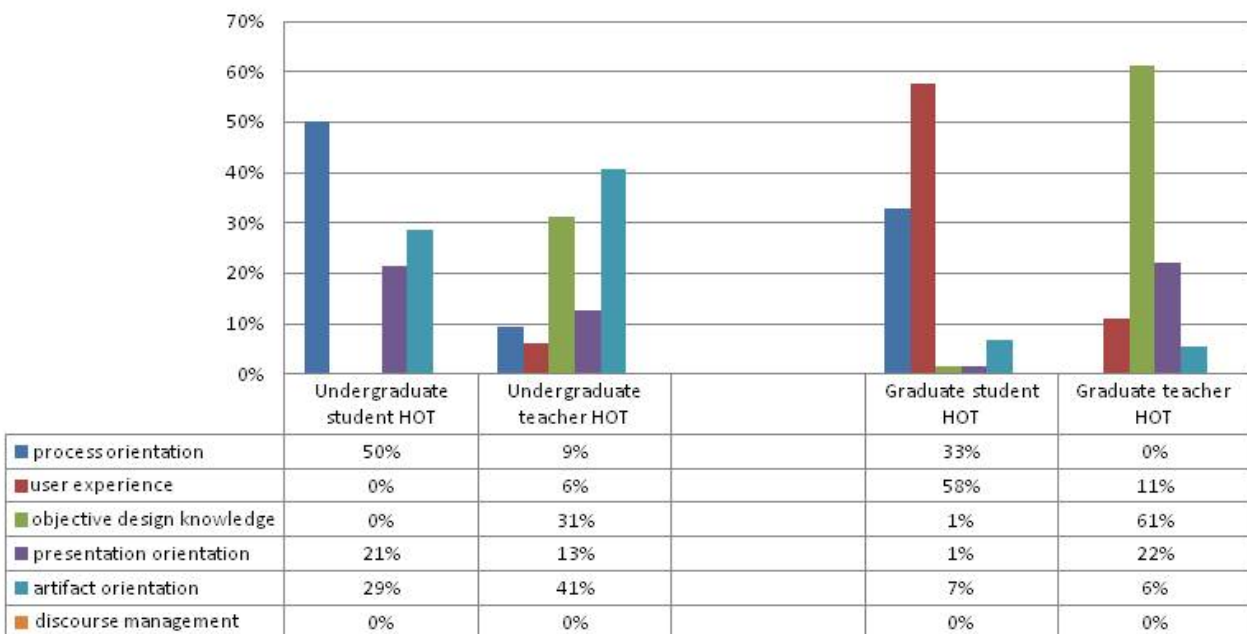


Figure 5: Higher order thinking turns from frames of reference normalized to the total number of higher order thinking turns in each role.

In the undergraduate review, the student showed a clear process orientation in his higher order thinking, whereas in the graduate design review, students grappled primarily with the user experience. The undergraduate teacher focused his most complex contributions to the learners' proposed artifact itself while the graduate teacher did so from the orientation of imparting objective design knowledge or pseudo-scientific principles of design. While each of the four

frames of reference profiles for higher order thinking is different, none are uniform or balanced across the different frames of reference. This suggests the indeterminacy of the learning of a design review. It does not appear that there was an attempt to balance the feedback or steer the review into a checklist of things needed to be addressed. From the student perspective, the higher order thinking as related to frames of reference does not appear to be balanced either. Concerns seem to be explored ad hoc, or organically, in both, according to interests, curiosities or concerns.

4. Implications and conclusions

Starting with a previous taxonomy (Howard, 2012), and keeping to the concepts of higher order thinking (Lewis & Smith, 1993; Krathwohl, 2002), led to an operational definition of higher order thinking as either narratives, gambits or justifications in the context of these two design reviews. However, we are aware that the size of the sample, and characteristics of the learning context, could have played a role in how higher order thinking emerged in these data. We did not interrogate the task for what higher order thinking it might elicit, nor did we attempt to uncover what prior experiences and abilities these learners might have brought to the design reviews that would steer their discourse in one direction or another. Both could have had an impact that we are unaware of using this type of analysis. We limit our claims to this group, and the higher order thinking we observed manifest in these design reviews, without making undo speculation as to cause for the dynamic we observed.

Whatever the cause, the strategies we focused on here hold value because of their transferability across different contexts (Resnick, 1987; Schön, 1987). The discourse within these reviews suggests that recounting experiences that led to design decisions, making gambits for possible design moves, and justifying decisions already made (Morton & O'Brien, 2006) are component parts of a larger design expertise, and may, at least partially, comprise the linguistic routines of a design review. As educators of design, it would be wise for us to recognize as many components of design expertise as possible in order to make more clear-sighted decisions about how we support design learning through our opportunistic practices. For example, calls for supporting the narratives surrounding designs have recently come to the fore in some fields of design (Boling 2010). If learners were made aware that telling of the story of a design is a requisite skill developed via the critique, some of the difficult feelings associated with the design review itself might be mitigated.

The shorthand narratives and co-constructed gambits also point to another feature of design expertise latent in the design review; higher order thinking in a design review may require a fair bit of speaking without saying in order to externalize some of the more complex relationships one might want to express. While the artifacts surely facilitated the reviews (McNair et al 2014), how that facilitation happens is exposed here via shorthand, as the artifacts themselves filled in phrases and clauses omitted from discourse without pause by either interlocutor. While it has been said before that communicating through the production of visuals is part of design communication (Schön, 1987), the role of those communication as an aspect of externalized higher order thinking that learners voice in a design review as component parts of narratives, gambits and justifications may not previously have been so obvious, at least to someone new to the scene.

These data evidence the indeterminacy of design learning, and the role agendas might play in the design review. In the context of the design review, it was curious that meta-cognitive strategies were not mentioned explicitly even though each teacher made a number of segues into objective design knowledge by bridging off the student produced material towards generalizations about design. Neither were theoretical models or heuristics invoked even though there is no shortage of these in industrial design and the teachers may have been well aware of them (Cardoso, personal communication). The differences in frames of reference among teachers and learners, as well as the recurrent diversions back to objective aspect of design knowledge and pseudo-scientific principles by teachers, suggests that the teaching happened opportunistically, rather than deterministically. Learners devoted their higher order thinking to different areas of concern. The ability for a student to make judgments and develop design character (Nelson & Stolterman, 2003; Gray & Howard, 2014) may in fact be intricately linked to these skills of applying higher order thinking to areas where the effort will be most fruitful. Presumably, the areas where these instructors were focusing their discourse, on the artifact in the case of the undergraduate, on design principles in the case of the graduate learners.

The teachers' emphasis on addressing frames of reference the learners may have steered away from may be tacit teaching tactics, where the teacher leads a discussion to areas not on a formal agenda, but where the teacher believes important learning will likely occur in an explorative fashion (Fanselow, 1987). These indeterminate teaching tactics rely on likelihoods that learners will pick up on implicit cues, e.g. *ah-ha, this is where I am supposed to apply the interrelation of ideas from the given frame of reference*. It may be difficult for learners, especially non-native speaking learners, to acquire these implicit linguistic routines without a more explicit focus, which suggests an instructional design tension within the instructional strategy of the design review and the organically acquired learning it is intended to foster. Superimposing an instructional structure might well render the facility of the design review useless in exploring these different higher order strategies in the fashion of real world design expertise.

In expressing the implications for design teaching and learning drawn from looking at higher order thinking in different frames in these two reviews, we want to be sure we do not intimate that we expect all undergraduate or graduate reviews to play out the same way—just the opposite. The differences between how higher order thinking played out was more remarkable than the similarities between the two reviews, especially when it came to the frames of reference where higher order thinking was applied in the different roles. The number of students in the reviews differed as well as the level, and it begs the question of how much can be predicted given the indeterminacy of the method, but it also allows us to question if there might be utility in fostering the learners' understanding of what to expect, even if it is to expect the unexpected. At a bare minimum, we would hope that learners would enter design reviews with an understanding that there is important learning meant to take place around how they tell the story behind their design, generate new directions, and justify the decisions that made.

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